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The Turbine Trip without Bypass Analysis for Lungmen ABWR Using TRACE/PARCS

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Abstract

The advanced thermal hydraulic code named TRACE for nuclear power plant (NPP) safety analysis is developing by U.S. NRC now. Lungmen NPP is the first ABWR NPP in Taiwan and still under construction. The safety analysis of NPP is very important work. In general, the description and results of the safety analysis for the transients are in the Final Safety Analysis Report (FSAR) of NPP. In this research, the development of the Lungmen NPP TRACE model for the safety analysis is performed. The turbine trip without bypass transient analysis of the TRACE model for Lungmen NPP is also performed. The turbine trip without bypass transient data from FSAR are used to compare with the predicted results of the Lungmen NPP TRACE model. The compared results indicate that there are the similar trends of parameters between the TRACE model of Lungmen NPP and FSAR for the turbine trip without bypass transient.

Keywords: TRACE;ABWR;Safety analysis

1. Introduction

The development of computer programs related to NPP safety analysis is one of the main R & D work in nuclear engineering. The U.S. NRC is developing an advanced thermal hydraulic code named TRACE for NPP safety analysis now [1]. NRC has determined that in the future, TRACE will be the main code used in thermal hydraulic safety analysis, which will be instead of the NRC's four main systems codes (TRAC-P, TRAC-B, RELAP5 and RAMONA). The development of TRACE is based on TRAC,

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integrating RELAP5 and other programs. Besides, SNAP, a graphic user interface program, which processes inputs, outputs, and the animation model for TRACE is also under development. One of the features of TRACE is its capacity to model the reactor vessel with 3-D geometry. It can support a more accurate and detailed safety analysis of NPPs. In transient analyses of BWRs (Boiling Water Reactors) and PWRs (Pressurized Water Reactors), TRACE has a greater simulation capability than the other old codes, especially for events like LOCA (Loss of Coolant Accident).

Taiwan and U.S. have signed an agreement on CAMP (Code Applications and Maintenance Program) which includes the development and maintenance of TRACE. INER (Institute of Nuclear Energy Research Atomic Energy Council, R.O.C.) is the organization in Taiwan that is responsible for the application of TRACE in thermal hydraulic safety analysis, for recording users' experiences of it, and providing suggestions for its development.

Lungmen NPP is the first ABWR NPP in Taiwan. It has two identical units with 3,926 MWt rated thermal power each and 52.2×10^6 kg/hr rated core flow. The core has 872 bundles of GE14 fuel, and the steam flow is 7.637×10^6 kg/hr at rated power. There are 10 reactor internal pumps (RIP) in the reactor vessel, providing 111% rated core flow at the nominal operating speed of 151.84 rad/sec. The FSAR of Lungmen NPP describes all kinds of the transients including the sequences and results of the safety analysis [2]. In this research, the TRACE safety analysis model of Lungmen NPP has been established and the turbine trip without bypass transient safety analysis of the Lungmen NPP TRACE model has been performed. The turbine trip without bypass transient data from FSAR are used to compare with the predicted results of the Lungmen NPP TRACE model.

2. The Lungmen NPP TRACE/PARCS safety analysis model

The Fig. 1 shows the TRACE safety analysis model of Lungmen NPP. In this TRACE model, the vessel is divided into 11 axial levels, four radial rings, and six azimuthal sectors (separately in 36°, 36°, 108°, 36°, 36°, 108° apart), and connected with four steam lines (connected to the 36° azimuthal sector of the vessel), six feedwater lines (connected to six azimuthal sectors separately, one for each sector), 18 channels which are simulated to the fuel region (one for each azimuthal sector in three inner radial rings), 10 RIPs (connected to six azimuthal sectors separately, one for every 36°). Besides, every steam line has one MSIV and some safety relief valves (SRVs). TRACE can couple with PARCS in the neutronic model and let PARCS calculate power.

PARCS is a multi-dimensional reactor core simulator which involves a 3-D calculation model for the realistic representation of the physical reactor while 1-D modeling features are also available. PARCS is capable to couple the thermal-hydraulics system code directly, such as TRACE, which provide the temperature and flow field information to PARCS during the calculations. Therefore, in Lungmen TRACE model, PARCS is used to calculate the power during transients. The control rods configuration and the rotation input of fuel assemblies are shown in Fig. 2.

Before the transient calculation of Lungmen TRACE model begins, it is necessary to carry out the steady state calculation and make sure that the system parameters (such as the feedwater flow, vessel steam flow, dome pressure, and core flow, etc.) are in agreement with FSAR data [1]-[4] under the steady state condition. The analysis results of TRACE/PARCS are clearly quite consistent with FSAR data under the steady state condition (See Table 1).

3. Results

Table 2 shows the turbine trip without bypass sequences in FSAR and TRACE/PARCS. Their sequences approximately are the same. Fig. 3 shows the neutron flux curves of FSAR and

TRACE/PARCS. The result of TRACE/PARCS is consistent with FSAR data. The increase of the neutron flux is caused by the turbine stop valves closing. The turbine stop valves closing make the decrease of the vessel's void which generates the positive reactivity. Then, the scram initiated and the neutron flux dropped. Fig. 3 also compares the steam dome pressure of FSAR and TRACE/PARCS. The trends of the curves are approximately in agreement. The turbine stop valves closing caused the dome pressure's rising. Then, SRVs opened and let the dome pressure decline. On the comparison of the other parameters (such as the feedwater flow, core flow, steam flow, etc.), their trends are also similar (see Fig. 4 and 5).

4. Conclusion

By using SNAP/TRACE, this study developed a TRACE safety analysis model of the Lungmen NPP. The turbine trip without bypass transient safety analysis of the Lungmen NPP TRACE model was also performed and the analysis results of TRACE compared with the FSAR data. The compared results indicate that there are the similar trends of parameters between the TRACE model of Lungmen NPP and FSAR for the analysis of the turbine trip without bypass transient. Therefore, the Lungmen NPP TRACE safety analysis model can be used in future safety analysis with confidence, such applications as for the prediction of Lungmen NPP startup tests.

References

[1] NRC. TRACE V5.0 User's Manual. Office of Nuclear Regulatory Research; 2010.

[2] Taiwan Power Company. Final Safety Analysis Report for Lungmen Nuclear Power Station Units 1&2 (FSAR); 2007.

[3] Kao L.S., et al. Parallel calculations and verifications of limiting transient analyses for Lungmen nuclear power plant. INER report, INER-A1609R. Institute of Nuclear Energy Research, Atomic Energy Council, R.O.C.; 2008.

[4] Kao L.S., et al. Development of Lungmen ABWR Thermal hydraulic Safety analysis Method-The Summary Report. INER report, INER-A1742R. Institute of Nuclear Energy Research, Atomic Energy Council, R.O.C.; 2008.

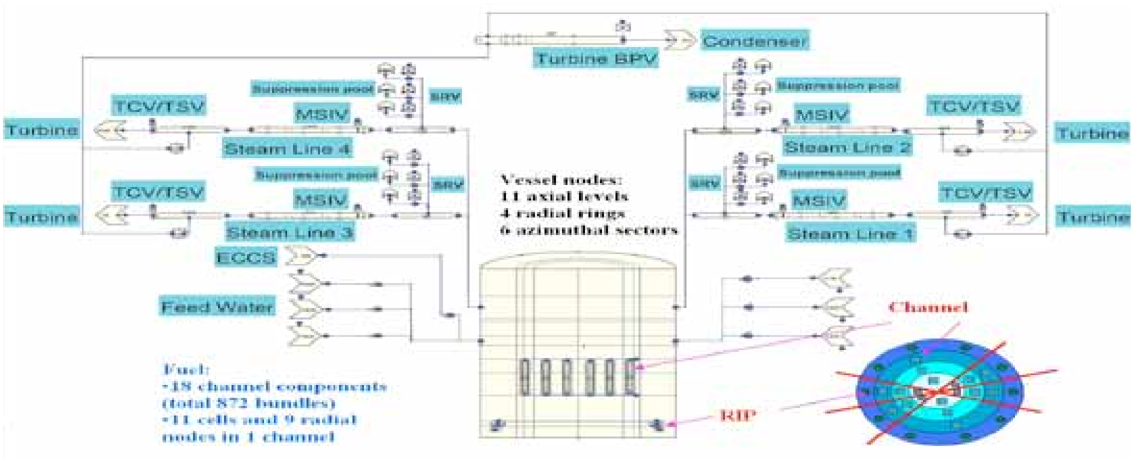
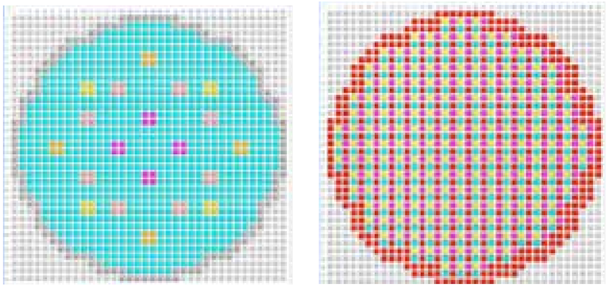


Fig. 1. The TRACE model of Lungmen NPP.



PARCS control rod positions and assembly rotations

Fig. 2. The PARCS model for Lungmen NPP.

Table 1 the comparison of initial conditions between FSAR and TRACE/PARCS

Parameters	FSAR	TRACE /PARCS	Error (%)
Power (Mwt)	3926	3926	0
Dome pressure (MPa)	7.1705	7.1244	0.99
Narrow range water level (m)	1.19	1.19	0
Steam flow (kg/sec)	2122	2033	0.96
Feedwater flow (kg/sec)	2122	2033	0.96
Core Inlet flow(kg/sec)	27176.6	27188	1

Table 2 The turbine trip without bypass sequences of FSAR and TRACE. [2]

Action	Time (sec)	
	FSAR	TRACE/PARCS
Turbine trip initiates closure of main stop valves	0	0
Turbine stop valves are closed.	0.10	0.10
Scram and RIP trip initiated	0.175	0.175
Trip of 4 RIPs	0.46	0.46
Safety/relief valves open due to high pressure	2.6	2.57
Safety/relief valves close.	9.2	9.99

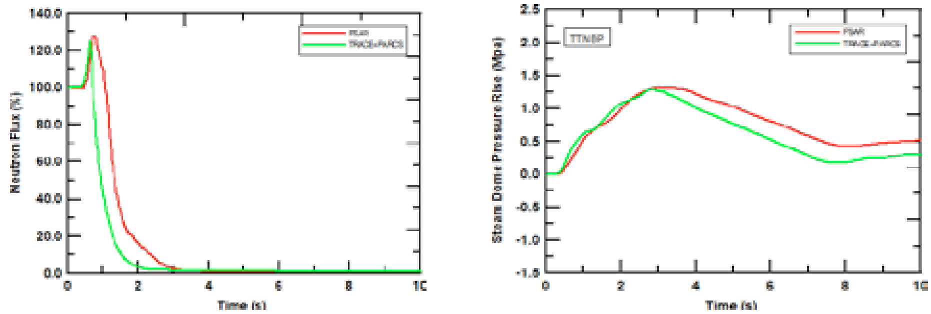


Fig. 3 The comparison of neutron flux and steam dome pressure between FSAR and TRACE.

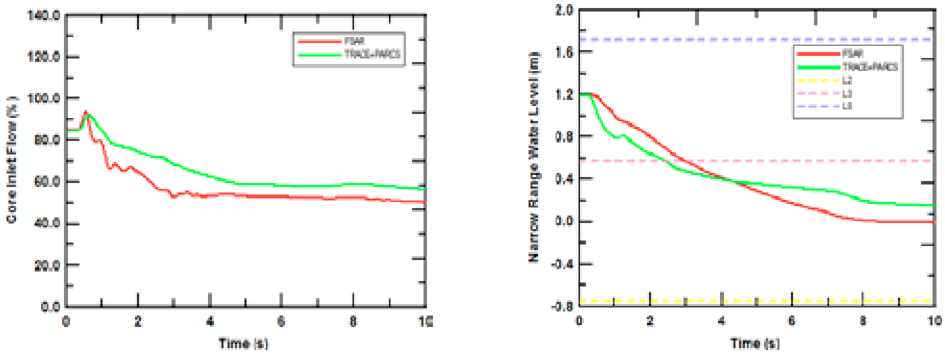


Fig. 4 The comparison of core inlet flow and narrow range water level between FSAR and TRACE.

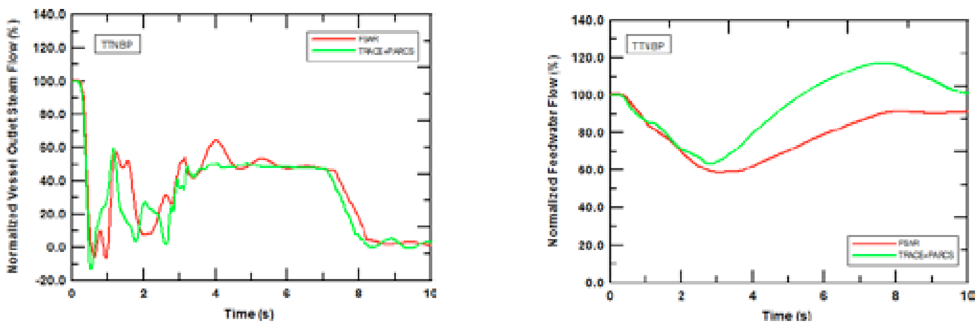


Fig. 5 The comparison of steam flow and feedwater flow between FSAR and TRACE.